

ADVANCED BATTERY & CAPACITOR PATENT EDGE

2018 Update

ABC PatentEdge Quarterly Report

What is Advanced Battery & Capacitor PatentEdge™?

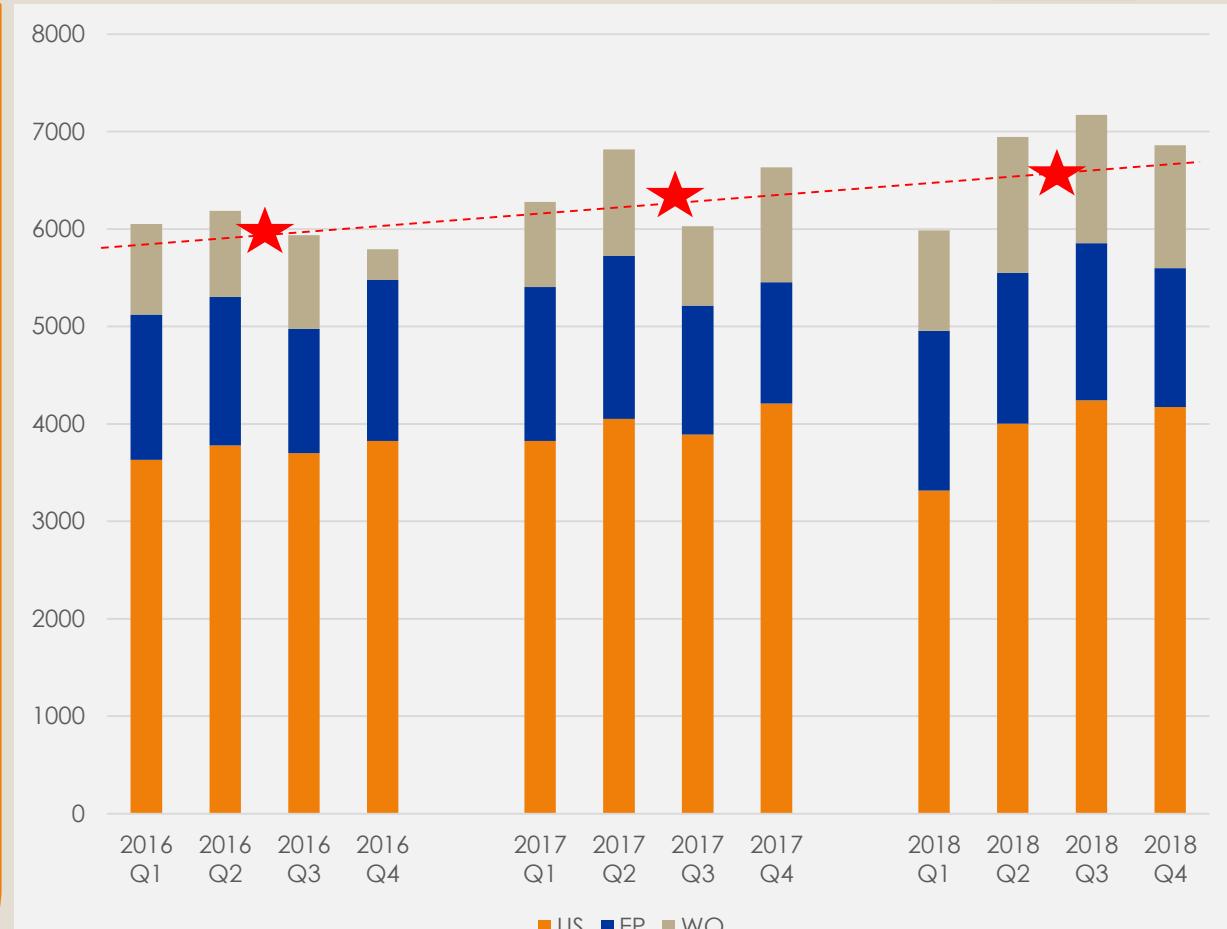
ABC PatentEdge is the only competitive patent intelligence solution specifically designed for the Advanced Battery market.

The ABC PatentEdge contains six high-level battery technology categories, developed by IP Checkups' along with industry leading battery technology experts. Within these six categories, there are 200+ technology and market-related sub-categories containing more than 250,000 patents published from worldwide* patenting authorities.

- Purpose:** The **ABC PatentEdge Quarterly** was developed to provide insight into recent advanced battery industry patent activity. As part of our partnership, IP Checkups provides this quarterly report to NAATBatt members as an exclusive value-add.
- Methodology:** The **ABC PatentEdge Quarterly** utilizes data from the **ABC PatentEdge** database to report on advanced battery trends and recent patent filing activity in specific battery technology areas.
- Sources:** Statistics reported in the **ABC PatentEdge Quarterly** were derived from the **ABC PatentEdge** database, which houses over 250,000 battery-related patents from the U.S. Patent & Trademark Office, the World Intellectual Property Organization, the European Patent Office.

Worldwide Patent Publications: 2016 – 2018

- Battery-related patent filings increased last year, with nearly 27,000 new publications in 2018 (there were about 25,000 in 2017).
- 2018 quarterly publication volume fluctuated between about 6,000 and 7,000 combined US, EP, and WO publications.
- EP publications generally remained steady during 2018.
- Since 2016, PCT (WO) publications have increased by about 1000 publications per year.

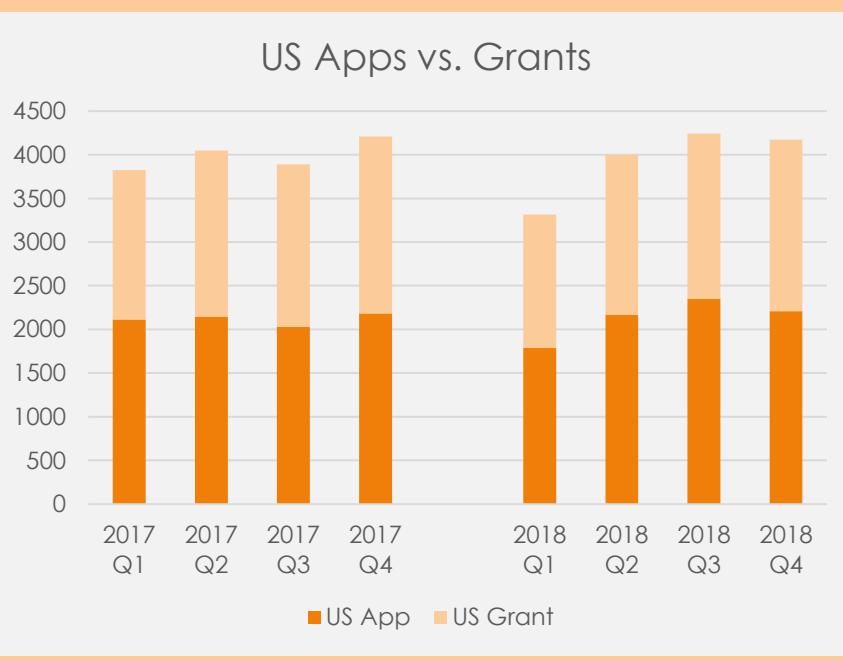


*Worldwide = U.S. published applications, U.S. granted patents, European (EP) published applications, European (EP) granted patents, World Intellectual Property Organization (WO) published applications

Worldwide Patent Publications: 2017 – 2018 US & EP App vs. Grant

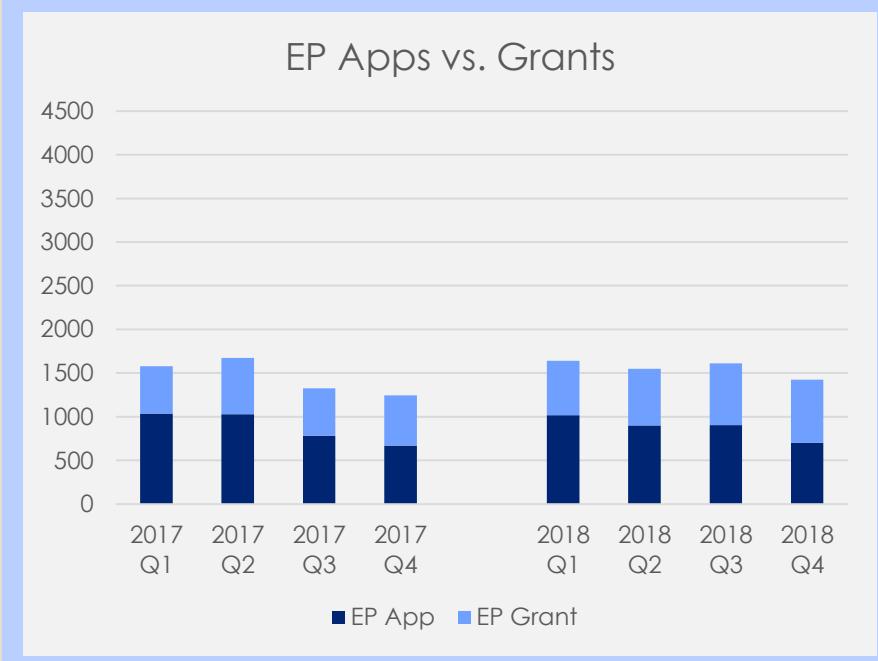
US filing trends in Battery technology appear to be steady, as there were about 2,000 published applications per quarter for the past two years.

The US patent issuance rate increased slightly each quarter in 2018.



The quarterly volume of EP published applications decreased over 2018, similar to the 2017 trend.

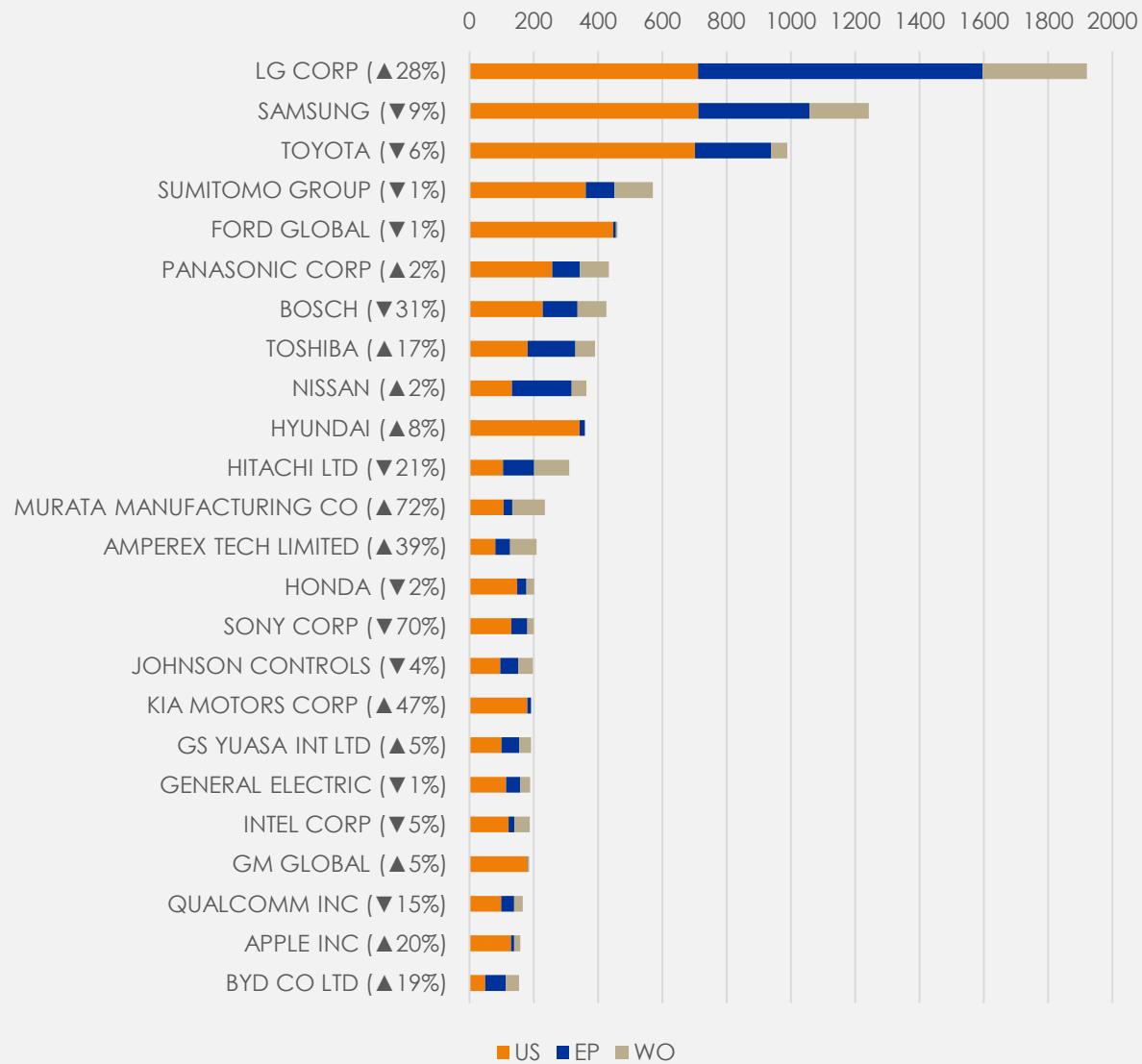
However, about 15% more granted EP patents were issued in 2018 than the previous year



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Top Worldwide Innovators

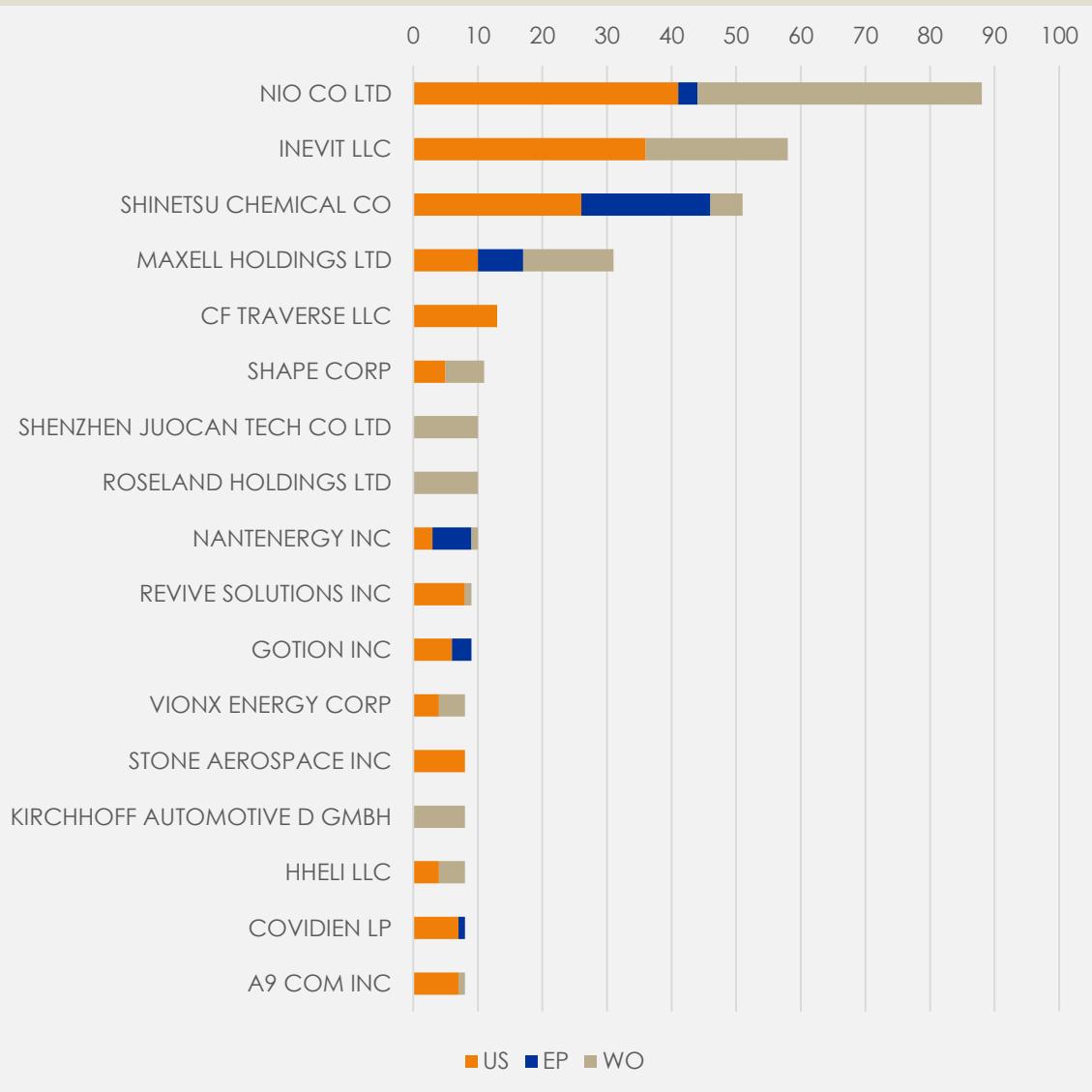
Top 20 Overall Assignees 2018: Worldwide Patent Publications



 In 2018, **LG**, **Samsung**, and **Toyota** continued to be the top assignees, together accounting for nearly 15% of worldwide battery-related patent publications.

 Among top-filing companies, the highest changes over 2017 were made by **Murata Mfg.** (+72%), **Sony** (-70%), **Kia** (+47%), and **Amperex** (+39%).

New Entrants 2018: Worldwide Patent Publications



This chart shows “New Entrants” - top companies filing in 2018 companies with no filings in the previous two years.

Nio Co is a Chinese automobile manufacturer headquartered in Shanghai, specializing in designing and developing electric autonomous vehicles.

InEvit is an electrical vehicle battery modularization started headed by former Tesla CEO Martin Eberhard.

Active Academic & Research Institutions: 2018

Academic/Research Institution	#	Academic/Research Institution	#
UNIV CALIFORNIA	84	UNIV SOUTHERN CALIFORNIA	10
MASSACHUSETTS INSTITUTE OF TECH	63	HARVARD COLLEGE	10
UNIV TSINGHUA	36	RESEARCH & BUSINESS FOUND SUNKYUNKWAN UNIV	10
INDUSTRIAL TECH RESEARCH INSTITUTE	35	UNIV SOUTH CHINA TECH	9
UNIV MICHIGAN REGENTS	32	UNIV KING FAHD PET & MINERALS	9
UCHICAGO ARGONNE LLC	31	UNIV WASHINGTON	9
UNIV TEXAS	29	UNIV TOKYO	8
BATTELLE MEMORIAL INSTITUTE	25	UNIV PRINCETON	8
UNIV CORNELL	24	ZHEJIANG GEELY AUTOMOBILE RES INSTITUTE CO LTD	8
UNIV LELAND STANFORD JUNIOR	22	UNIV NANYANG TECH	8
UNIST ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECH	19	NAT UNIV SINGAPORE	8
UNIV ILLINOIS	16	RAMOT AT TEL AVIV UNIV LTD	8
UNIV KING ABDULLAH SCI & TECH	15	THE REGENTS OF THE UNIV OF COLORADO	7
UNIV MARYLAND	15	UNIV DE PICARDIE JULES VERNE	7
SEOUL NATIONAL UNIV R&DB FOUNDATION	13	UNIV WASEDA	7
UNIV CASE WESTERN RESERVE	12	UNIV NEW YORK STATE RES FOUND	7
UNIV RICE WILLIAM M	12	UNIV ARIZONA STATE	7
UNIV DE NANTES	12	UNIV MICHIGAN STATE	7
GRADUATE SCHOOL SHENZHEN TSINGHUA UNIV	12	KOREA INSTITUTE OF INDUSTRIAL TECH	7
UNIV NORTHWESTERN	11	HANYANG UNIV	7
RESEARCH INSTITUTE OF INDUSTRIAL SCIENCE & TECH	11		

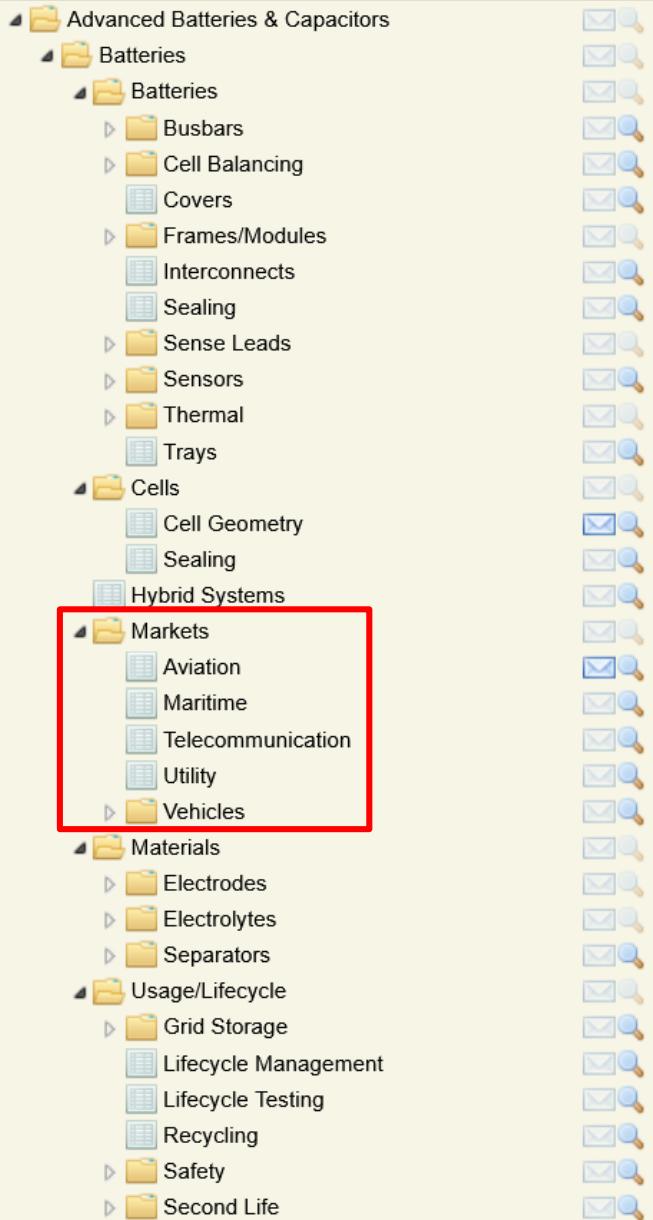


These academic universities and research institutions were the leaders in advanced battery related published patent applications in 2018.

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Patent Activity in Key Battery Technology Sectors

ABC PatentEdge Hierarchy



Within the ABC PatentEdge™ database, there are six main high-level categories.

- Battery Modules
- Cells
- Hybrid Systems
- Markets
- Materials
- Usage/Lifecycle

There is significant overlap between categories, particularly between Markets (i.e. End Use) and technical sectors such as Battery Modules, Materials, and Usage/Lifecycle.

This year, IP Checkups inspects the Vehicles Market category, and in particular the overlap between Vehicles and Battery Modules, Materials, and Usage/Lifecycle.

PatentCAM enables users to compare the overlap between multiple categories.

Worldwide Patent Publications in Battery Sectors: Full Year 2018

Overall Sector Activity

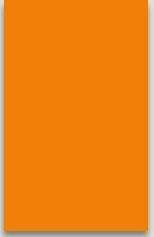


Sector Activity Change from 2017 to 2018

		US		EP		WO	
		App	Grant	App	Grant	App	
Battery Modules		▲ 196 (9%)	▼ -192 (-8%)	▲ 105 (11%)	▲ 109 (15%)	▲ 225 (20%)	▲ 443 (6%)
Cells		▲ 30 (45%)	▼ -17 (-21%)	▲ 24 (69%)	▲ 7 (14%)	▲ 15 (41%)	▲ 59 (22%)
Hybrid Systems		▼ -92 (-26%)	▼ -7 (-2%)	▼ -35 (-19%)	▲ 37 (38%)	▲ 5 (3%)	▼ -92 (-8%)
Markets		▲ 30 (1%)	▼ -17 (%)	▼ -48 (-3%)	▲ 190 (19%)	▲ 866 (80%)	▲ 1021 (9%)
Materials		▼ -147 (-5%)	▼ -218 (-10%)	▲ 134 (10%)	▲ 158 (17%)	▲ 207 (11%)	▲ 134 (1%)
Usage/ Lifecycle		▼ -358 (-14%)	▼ -478 (-22%)	▼ -158 (-18%)	▲ 167 (30%)	▲ 70 (9%)	▼ -757 (-11%)
		▲ 34 (%)	▼ -288 (-4%)	▼ -266 (-8%)	▲ 395 (17%)	▲ 1040 (26%)	▲ 915 (4%)

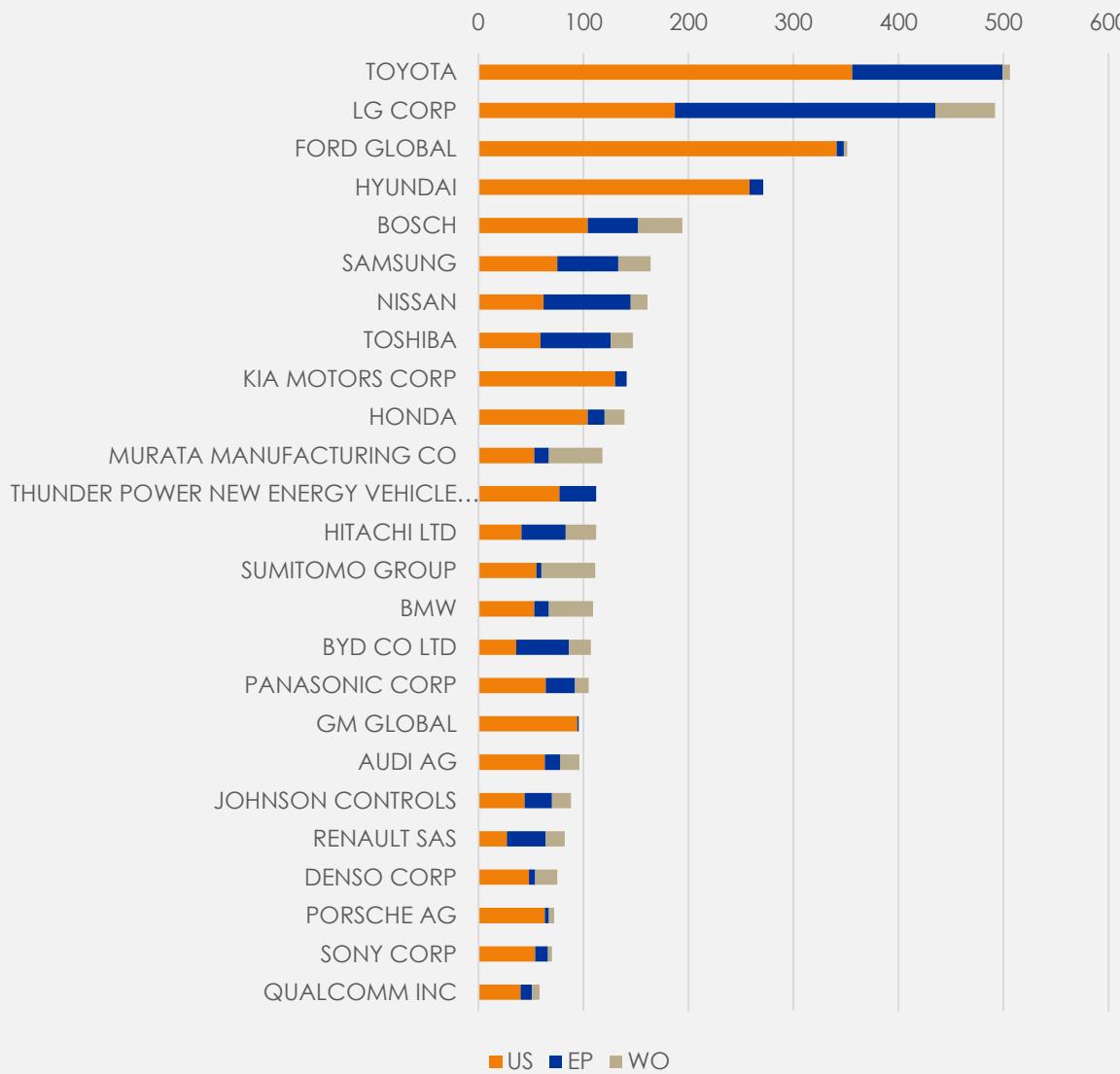
- In 2018, overall publication rates increased 4%, with the most notable sector increase in *Battery Cells*, 26%.
- While there was a net decrease in US publications, the volume of EP patents granted in 2018 increased 17% over 2017.
- The largest sector publication volume increase was in PCT (WO) applications relating to *Battery Markets* (up 80%).

*Note that many patents are categorized in multiple categories.



Spotlight on Battery Innovation in the **Vehicles** Sector

Top Assignees: Vehicles – 2018



Toyota, LG, Ford, and Hyundai lead the pack in IP related to Vehicle Battery technology.

LG, Nissan, Toshiba, BYD, Hitachi and Renault have budgeted heavily on IP protections in the European market.

Most other companies appear focused on US protection, including LG, Ford, Hyundai, and Kia.

The increase of innovation by multinational electronics manufacturers in the Vehicle sector may indicate a convergence of technology and business strategies.

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Top Assignees: Vehicle by Sector

Top companies publishing patents in the Vehicle Battery sector are filing steadily in every sub-category (except Cells).

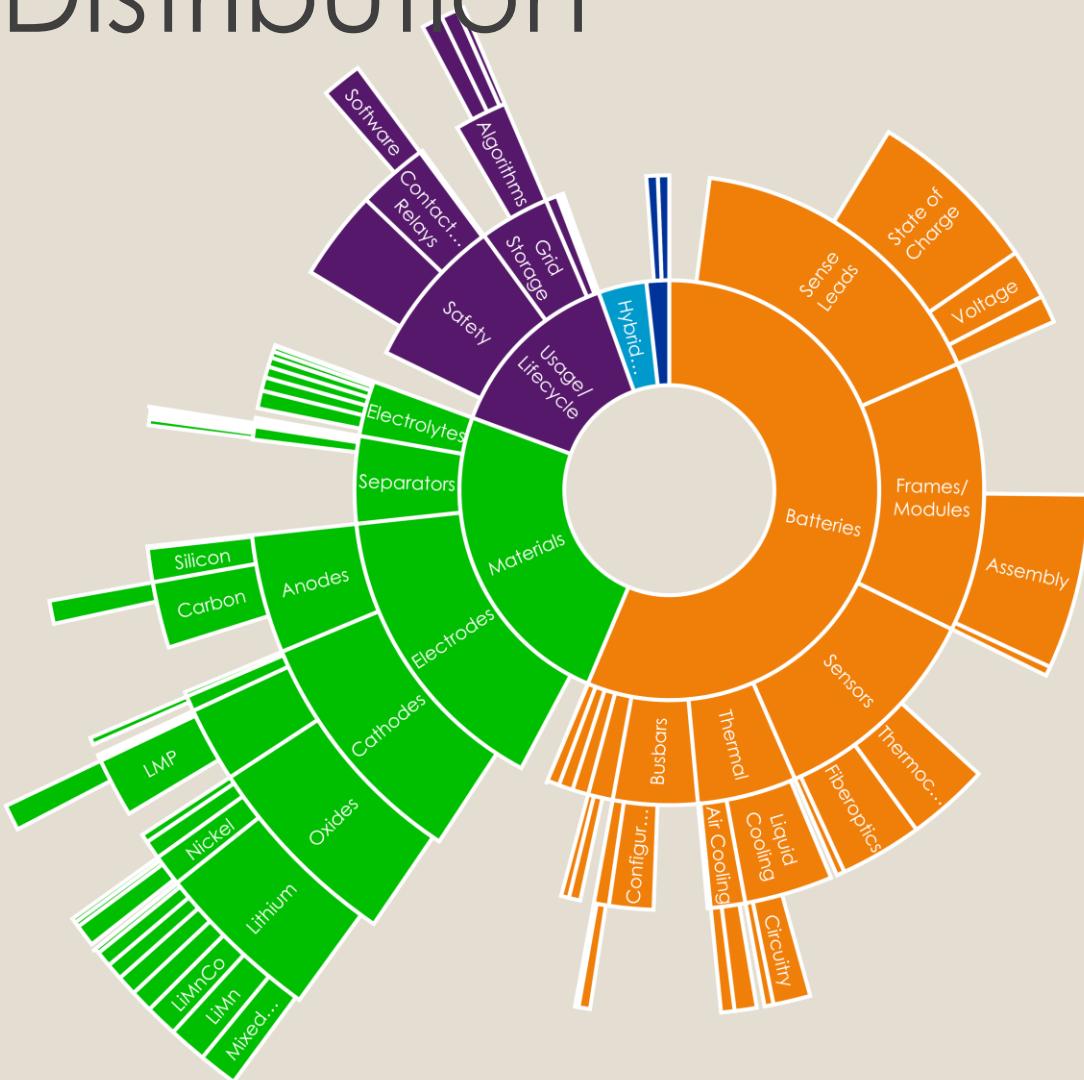
Top companies are still innovating in the Hybrid Systems space, including Toyota, Ford, Hyundai, Nissan, Kia, and BYD.

LG and Toshiba focus on IP related to battery materials in the vehicle space.

LG is the only assignee focused on Battery Cells.

Assignee	Battery Modules	Cells	Hybrid Systems	Markets	Materials	Usage/Lifecycle
TOYOTA	158	2	35	506	42	43
LG CORP	335	35	2	492	104	91
FORD GLOBAL	147	3	41	351	8	15
HYUNDAI	104	1	45	271	5	17
BOSCH	71	3	12	194	22	17
SAMSUNG	85	0	8	164	15	19
NISSAN	36	1	23	161	4	1
TOSHIBA	19	0	2	147	78	44
KIA MOTORS CORP	49	0	20	141	1	7
HONDA	44	0	4	139	6	5
MURATA MANUFACTURING	18	0	0	118	52	26
THUNDER POWER	70	0	0	112	2	7
HITACHI LTD	61	0	9	112	8	14
SUMITOMO GROUP	27	0	1	111	2	10
BMW	37	1	8	109	8	2
BYD CO LTD	41	3	25	107	9	13
PANASONIC CORP	18	0	2	105	3	12
AUDI AG	35	0	3	96	8	9
GM GLOBAL	54	0	7	96	11	10
JOHNSON CONTROLS	57	3	5	88	11	40
RENAULT SAS	42	0	18	82	3	5
DENSO CORP	20	0	2	75	5	3
PORSCHE AG	28	1	2	72	11	2
LITHIUM ENERGY & POWER	28	2	1	48	18	18
VOLVO TRUCK CORP	27	0	2	39	0	7
JAGUAR LAND ROVER LTD	26	1	6	37	0	4

2018 Vehicle Sector Patent Distribution



■ This chart shows the distribution of 2018 Battery-related Vehicle publications within the category hierarchy.

■ Many of the Vehicle related publications fall into multiple categories.

■ The inner circle shows each of the 5 technical battery sectors by volume, with sub-categories branching from the inner circle (the Markets sector is not shown here to reduce redundancy).

■ Vehicle innovations were primarily focused on Battery Modules, Materials, and Usage/Lifecycle topics.

2018 Advanced Battery Summary

- Battery-related patent filings increased last year, with more than 27,000 new publications in 2018 (there were about 25,000 in 2017).
- 2018 quarterly volume hovered around 7,000 combined US, EP, and WO publications.
- U.S. activity followed the quarterly trend, and again outpaced EP and WO filings.
- While there was a net decrease in US publications, the volume of EP patents granted in 2018 increased 17% over 2017.
- In 2018, **LG**, **Samsung**, and **Toyota** continued to be the top assignees, together accounting for 15% of worldwide battery-related patent publications.
- The increase of innovation by multinational electronics manufacturers in the Automotive sector may indicate a convergence of technology and business strategies.
- Automotive innovation was primarily focused on Battery Modules, followed by Materials and Usage/Lifecycle topics.
- Drill-downs on Assembly, Li-Oxide Cathodes, and Grid Storage reveal valuable insights, including investment details of multi-nationals, and the presence of new innovators.

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With ABC PatentEdge...

- Track worldwide patent filing, publication and issuance trends in more than 200 advanced battery related tech categories
- Identify which patents have been assigned to which companies
- Learn what trends within specific technologies are developing
- Identify key thought leaders in different technical areas
- Review patent activity coming from universities and research institutions filing patents in particular technology areas
- Find out where leading companies are really making their bets

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